

DRAM Market: A Rollercoaster Ride

Name: Jim Feldhan

Company: Semico Research Corp.



San Jose January 23-24, 2001



Taipei February 14-15, 2001

Semico Methodology

- Economy
 - Macro View
- Systems
 - Applications Drive the Market
- Market by Segment
 - SIA Categories
- Devices
 - Interdependence
- Manufacturing
 - Foundry/Capacity

The Economy Slows

- Overall economy showing signs of a slowing on the consumer sector, particularly in Autos
- Semiconductor industry growth is slowing
- All IC product markets will grow at half the 2000 rate
- Supply supply side of equation
 - Plant delays or cancelled
 - Equipment deliveries pushed out
- Prices are weakening
- End markets remain strong through 2001 but will grow at a slower rate

The Golden Age for the Economy

- 120+ Months of Expansion
 - Inflation is up primarily due to energy
 - Unemployment hovering at 4%
 - Record Federal surplus projections
 - Productivity continues to increase
 - Asia in expansion
 - Dollar high compared to other currencies
 - GDP slowed faster than expected in 2nd half 2000

Economic News

- Signs of slowing Consumer Sector
 - *Housing starts recover to 1.53 million after hitting their lows in June of 2000, but still off the high of Feb. at 1.82*
 - *Non-farm payrolls rose by 94,000 jobs in November, Employment was stronger in the 1st half of 2000 than the 2nd half*
 - *Unemployment was 4.0% in November 2000*
 - *Durable orders decreased 5.5% in October to \$209B*
 - *Transportation down 15.8%*
 - *Electronics down 9.9%*
 - *Primary metal down 3.2%*
- Economy growing a little slower

Important DRAM Markets

- Servers
 - NAS, Cache, Print, All-in-One
- PCs
 - Desktop, Notebook and Handheld PCs
- Communications
 - Switches, Hubs, Routers, ATM Switches, Set Top Box
- Wireless Communication
 - Cellular Base Stations, 3G Cell Phones, Smart Phones
- Consumer
 - Digital Camera, Video Games, Internet Appliances

End Market Growth Forecasts for 2001

- Desktop PC +10.9%
- Notebooks +26%
- Servers +22%
- Workstation +11%
- Printers +11%
- Switches +35%
- Routers +14%
- Handheld PCs 19%
- Smart Phones +96%
- Base Station +40%
- Digital Cameras +41%
- HDTV +186%
- Video Games +18%

Resulting Shift in Semiconductor Product Strategies

- Influence of high-end PCs is decreasing
 - High-end PC growth is declining
 - Consumer trend is toward low-end PCs
 - Business trend is toward portability
- Increased emphasis on expanding the capacity of communications systems
- Increased emphasis on Embedded Processor Applications

Quarter DRAM Review

- The good news of strong second and third quarter revenue was lessened by the downward ASP trend in September
 - Aggregate ASPs drop by 8.7 percent between August and September
- 3Q00 Revenue Up 18.8%
 - July and August revenue and unit shipments strong
 - September Revenue down 15%
- 3Q00 Unit shipments drop 5.0%
 - September Unit shipments down 7%
- Lowest bit growth rate (63.5 percent) since 1993

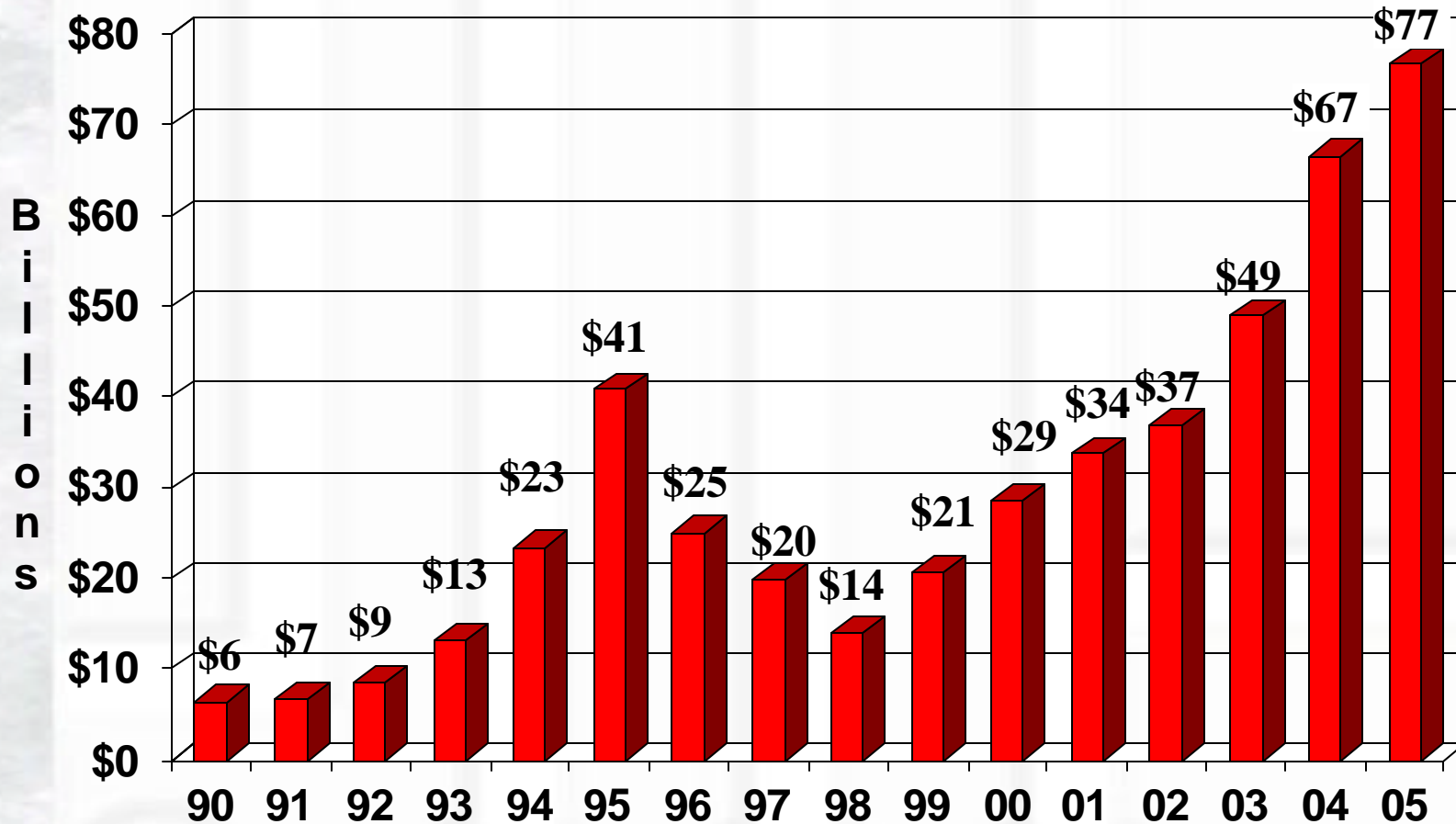
2000 Recap

- 2000 Grew to \$28.6 Billion - 38% increase
 - Tight supply in second quarter turned by September to oversupply – forecast to continue through 1Q01
 - Desktop PC memory size holds at 128 megabytes
- Fourth Quarter revenue plummeted 33%
 - ASPs plunged and demand disappeared
- First Quarter revenue forecast to be flat
 - ASPs and Unit shipments stabilize
- High demand in 2Q00 through August was inventory build-up to hedge against potential 2H00 higher prices

2001 Revenue Forecast

- 2001 forecast 18.5% Growth – \$33.8 Billion
 - **2001** does not yet exceed revenue high of 1995
 - ASPs stable to up as mix, demand and controlled capacity cause shortages
 - Capacity additions will be scrutinized by most DRAM vendors and delayed
 - Capacity additions already planned cannot be added quickly enough to impact the market until 2H01
 - Diversification of DRAM market to impact supply
 - EDO, SDRAM, DDR SDRAM and RDRAM all in production

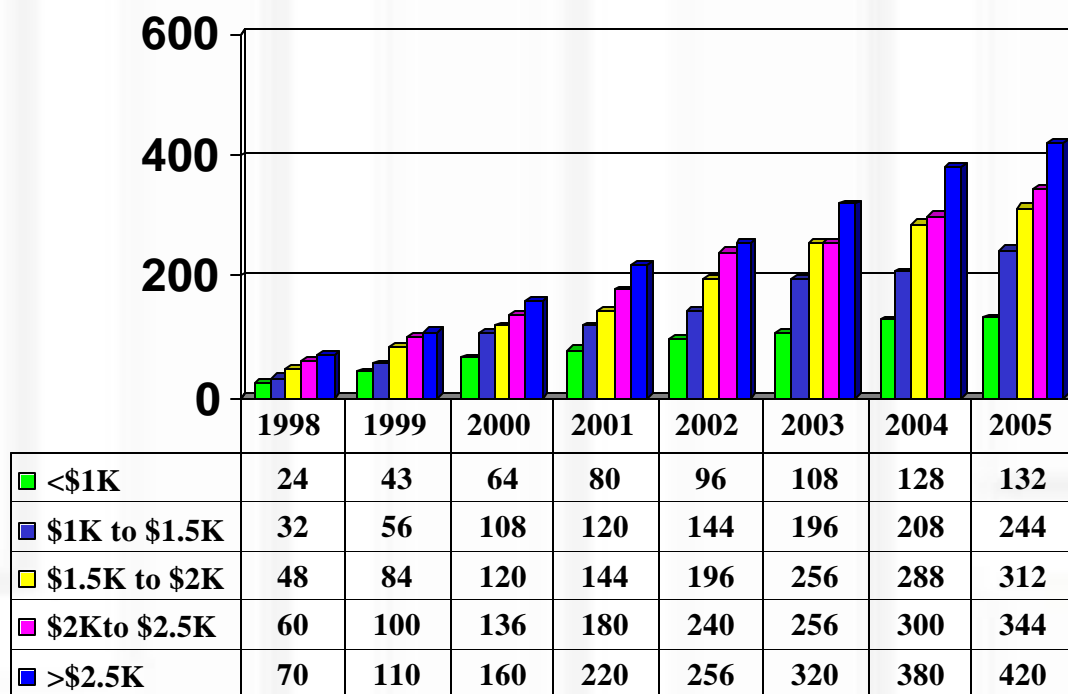
Worldwide DRAM Market Revenue



PC Memory

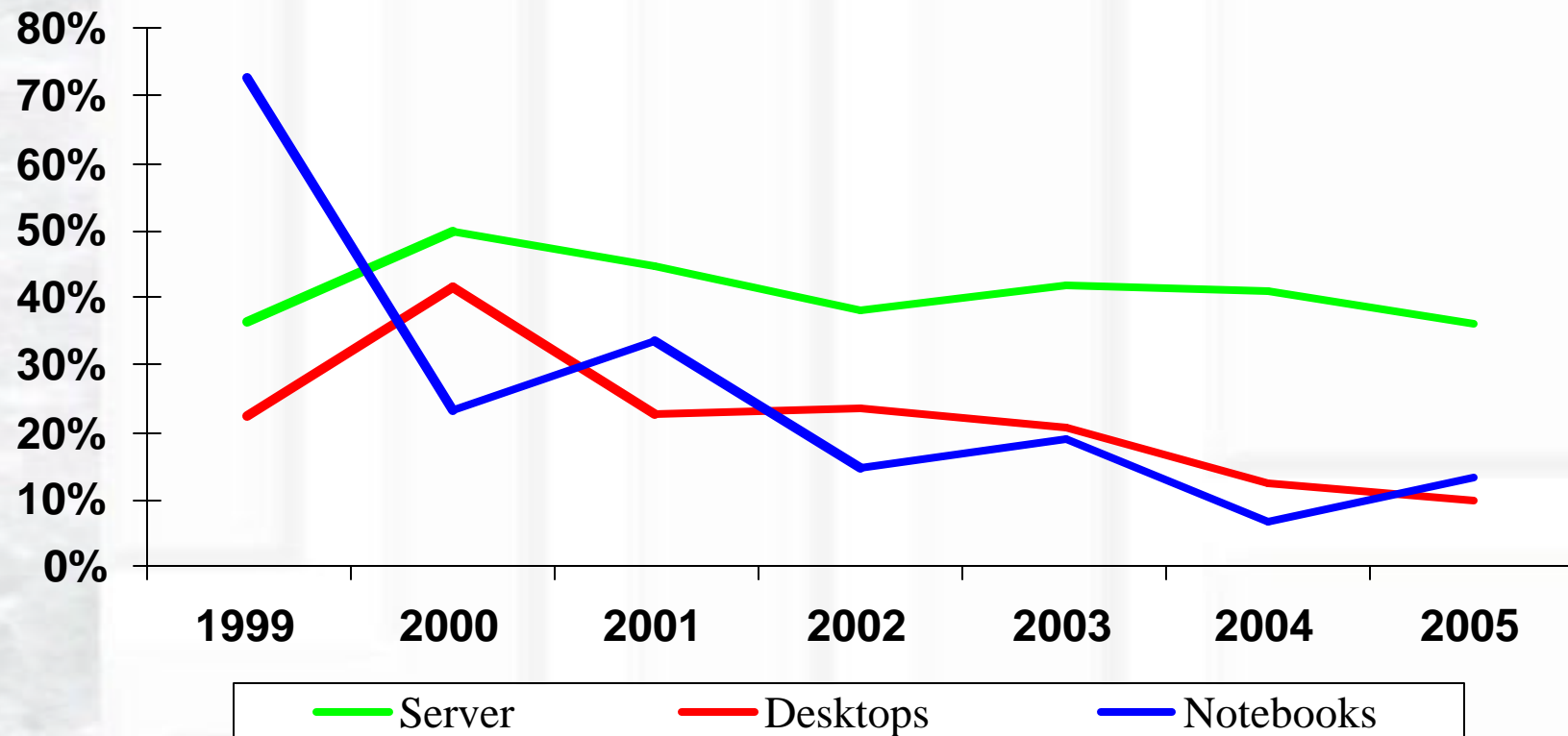
- Desktop PC memory sizes not doubling yearly
 - Price points are key to memory size
- Notebook PCs are becoming nearly comparable to desktops in features
- Sub-portable or Handheld memory sizes are growing also
- Server Memory growing fastest

Desktop PC Average Memory

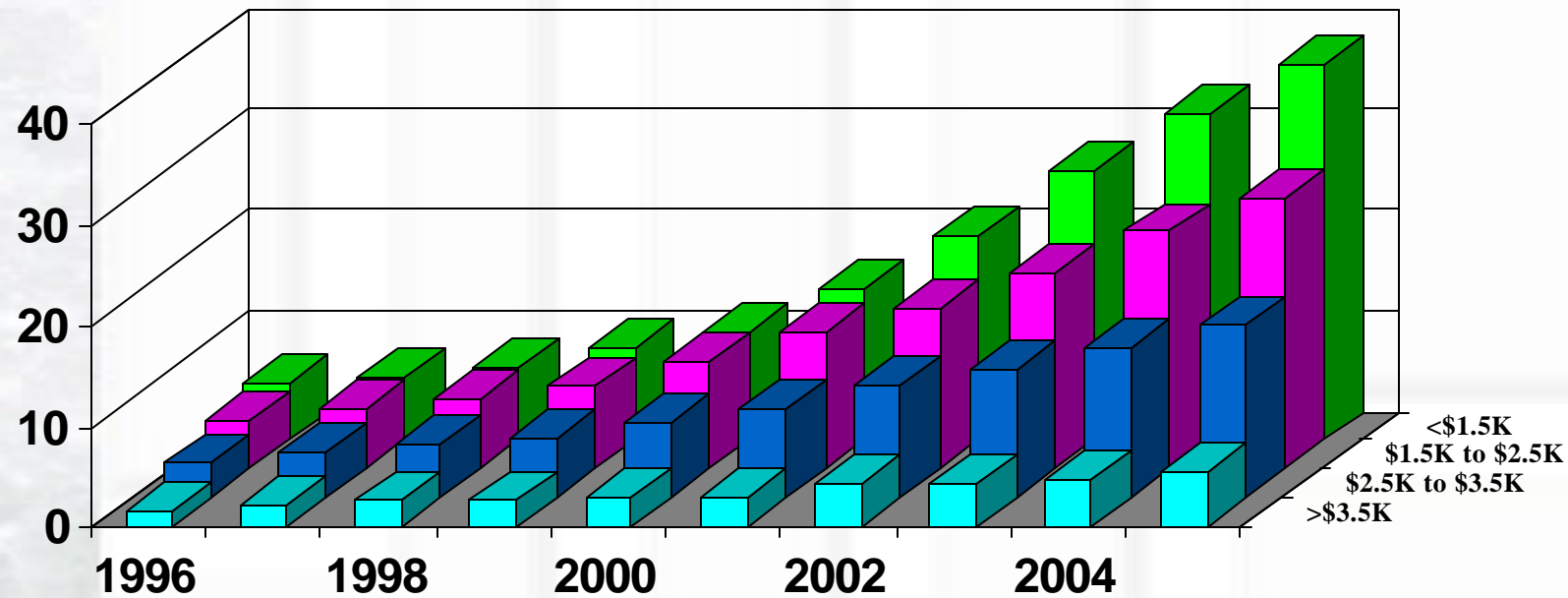


■ <\$1K
 ■ \$1K to \$1.5K
 ■ \$1.5K to \$2K
 ■ \$2Kto \$2.5K
 ■ >\$2.5K

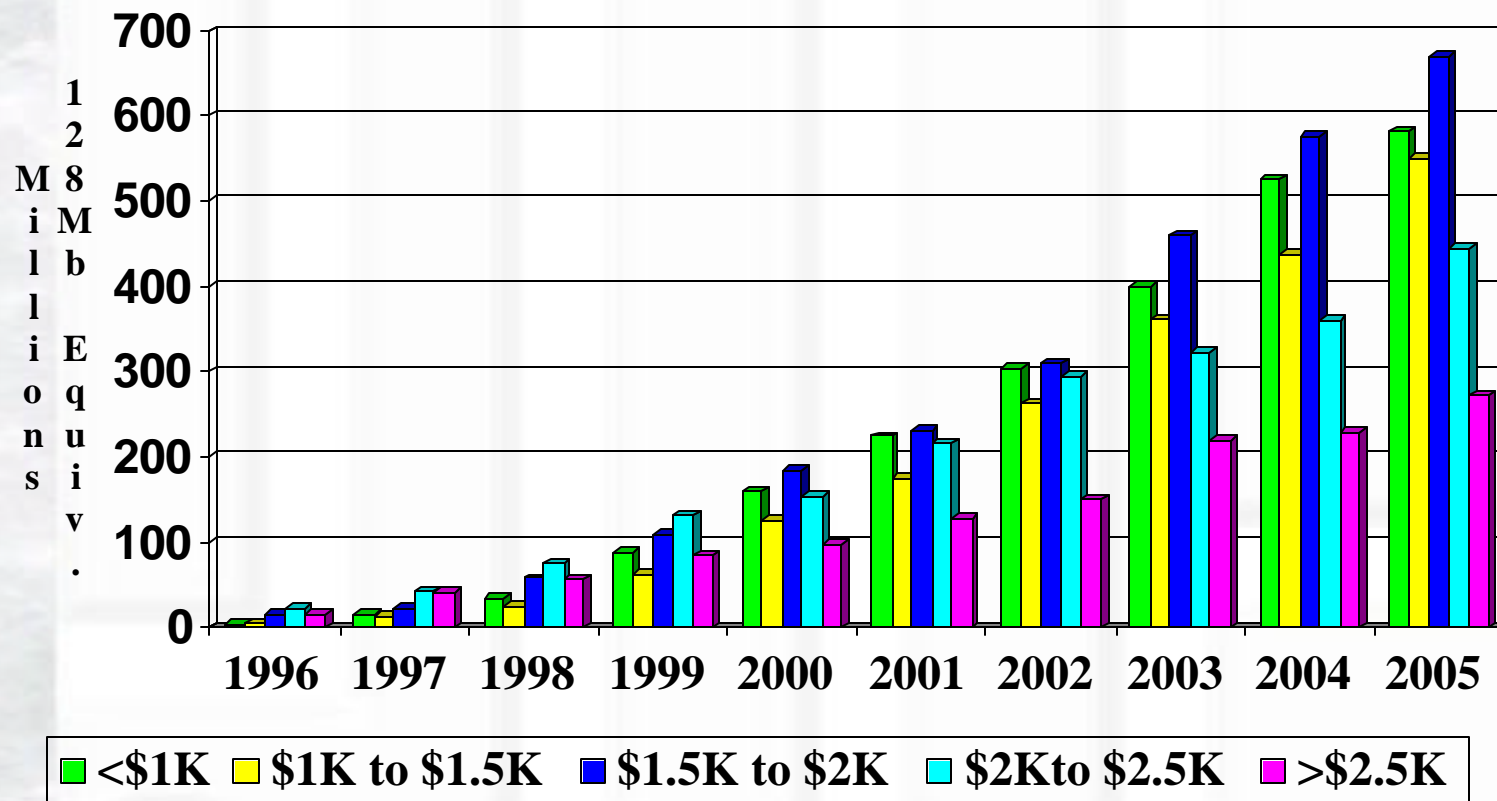
Percent Change of Average Megabytes per System



Desktop Shipments by Price Point



128Mbit Consumption by Desktop Price Point



PC Platform Trends - Chipsets Merge with Graphics

- Driven by further reduction in PC component count
- High performance graphics requires separate components

	Intel	Intel	Intel	ALi	SiS	SiS	VIA	VIA	Nvidia
Part Name	810e	815e	Almador	TNT2	315	730S	KM133	PM133	N/A
South Bridge	ICH2	ICH2	ICH2	1535D	960	960	82C686	82C686	N/A
PC Target	Low-end desktop	Mid-range desktop	Low-end desktop	Mid-range desktop	Low-end desktop	Mid-range desktop	Mid-range desktop	Mid-range desktop	Mid-range desktop
Processor	Celeron	PIII	PIII	PIII	PIII	Athlon	Athlon	PIII	PIII
Graphics Engine	Intel 740	Intel 740	Intel 740	Nvidia Riva	Internal Design	Internal Design	S3 Savage4	S3 Savage4	Nvidia GeForce
Memory	PC100	PC133	PC133	PC133	DDR	PC133	PC133	PC133	DDR
Status	Avail.	Avail.	2Q01	Avail.	1Q01	Avail.	Avail.	Avail.	2Q01

PC Platform Trends - Support of IEEE1394

- Competition between 1394 and USB heightened by the merger of data and entertainment for home networks
- Issue is the future architectural structure of home networks
 - 1394 supports a peer-to-peer structure with a passive bus
 - USB supports a hierarchical structure with a PC-like host to arbitrate bus usage

PC Platform Trends - SDRAM Developments Continue

- All Chipset manufacturers now have PC133 and DDR support on their roadmap
- Servers and most PC segments have Chipset support for PC133 or DDR
 - Pentium 4/DDR is announced for servers but not for PCs, but DDR support should be announced in the near future
- SDRAM continues to have the lowest cost/bit

Chipset Progress - Consumers Wait For DDR

- Intel data on 815/PC133 and 820/RDRAM shows no compelling reason for RDRAM with P3
- Athlon introduced with DDR
- Intel is introducing P4 with RDRAM but hints at DDR support for consumer PCs
- VIA, ALI, SIS chipsets available 1Q01 for P3/DDR
- P4/DDR chipsets could be made available quickly, but are not yet licensed by Intel

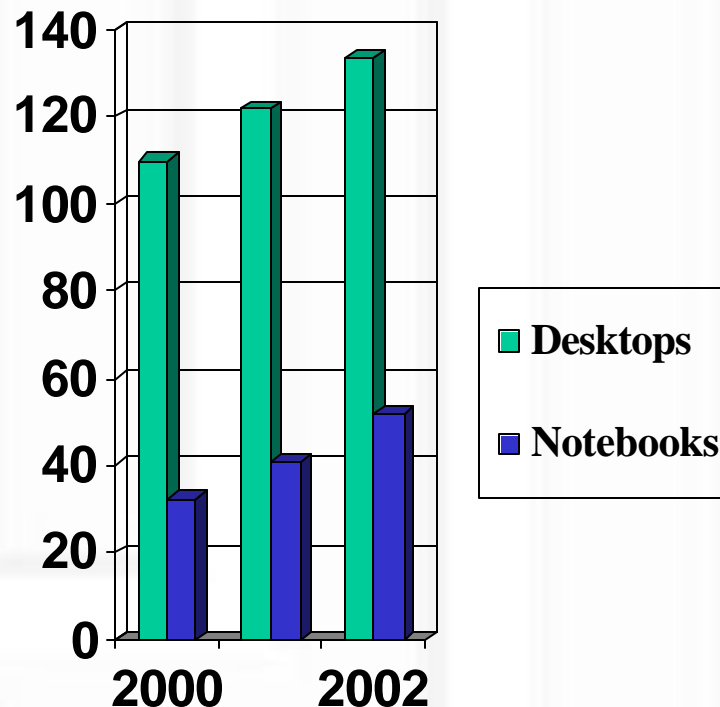
DDR Availability Will Not Be a Critical Issue

- Overall DRAM memory supply is positive
- DDR is a natural evolution of SDRAM
- It is reasonably simple for DRAM companies to manufacture both PC133 and DDR
- DDR is metal mask option of PC133 in many cases

PC Platform Drivers for 2001 and 2002

- PC growth slows down
 - New applications restricted by external data rates
- Rollout of Pentium 4
 - Displacement of Pentium 3 by .13 micron Pentium 4

PC Growth Slows



- Forecast of combined growth of Desktop and Notebook is 14.3% in 2001 and 14.1% in 2002
- Fastest growth rate is in the lower performance segments

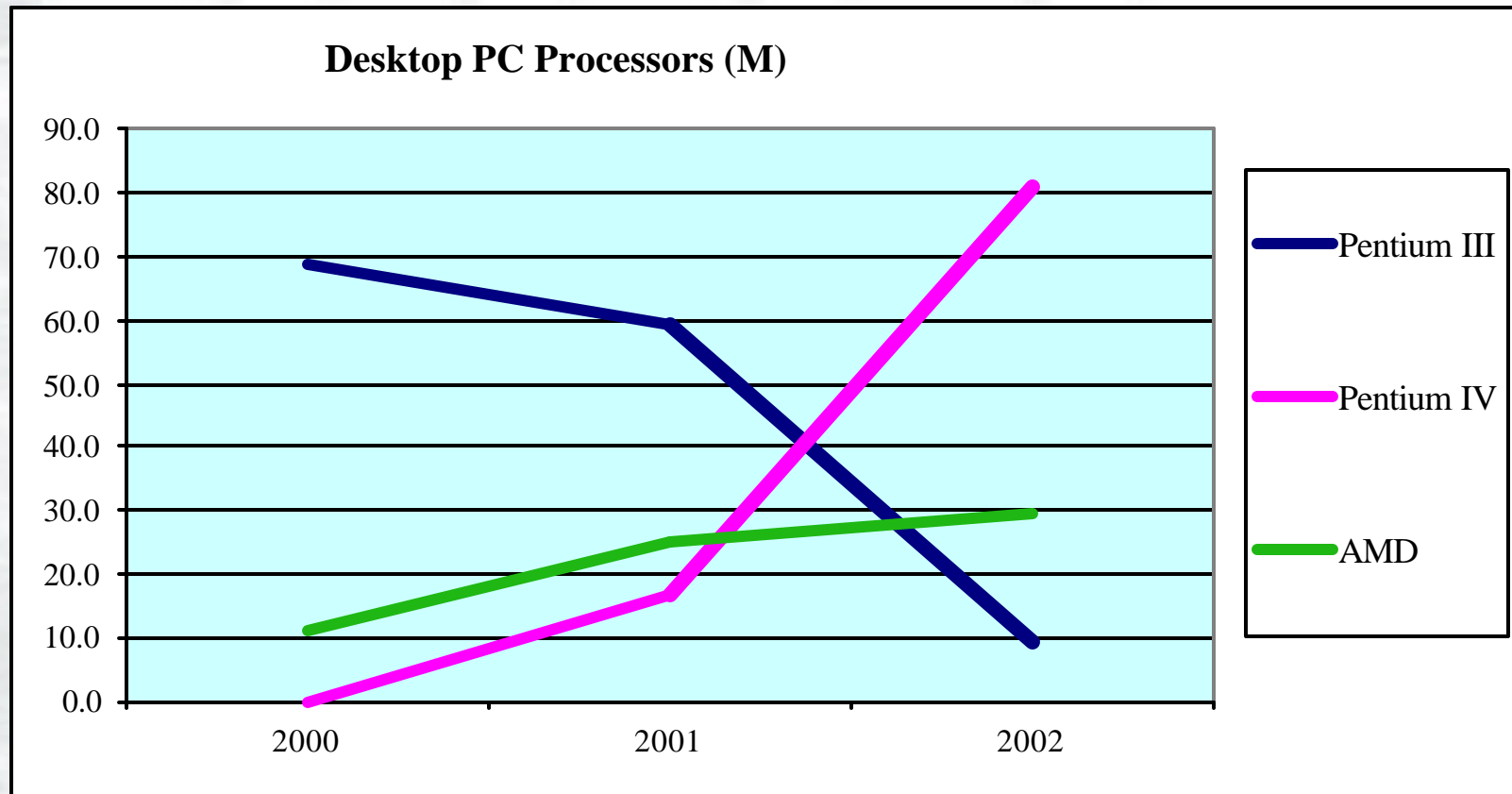
Pentium 4 Rollout in 2001

- Memory and Chipset issues
 - Intel to release SDRAM/DDR chipset in 2H '01
 - If released late in 2H '01 could hamper MPU ramp-up
 - Third party SDRAM/DDR chipsets are expected, but no official announcements
 - If available in 1H '01 will help Pentium 4 ramp-up
 - Delay of Pentium 4 SDRAM/DDR chipset will retard MPU ramp-up and reduce forecast
- Slower Pentium 4 ramp-up provides greater opportunity for AMD

Intel Process Migration 0.18 to 0.13

- Intel currently manufacturing on 0.18 micron
- Pentium III is migrating to 0.13 micron
 - Enables faster Pentium III (over 1.1 GHz)
 - Validates and prepares new process for Pentium 4 migration
- Pentium 4 expected to migrate to 0.13 micron process by mid-2001
 - Improve yields
 - Lower power and higher frequencies (over 2.0 GHz)
 - Enables future mobile Pentium 4
- If process migration is delayed, Pentium 4 ramp will slow.

Impact of Migration from Pentium III to Pentium IV



Semico's PC Outlook

- Estimated 80M Desktop PCs in 2000 with P3 or AMD processors
- Forecast of over 85 million Desktop PCs in 2001 with P3 or AMD processors
 - P3 with .13μ will migrate P3 to lower performance applications
 - Intel's chipset focus is on Pentium 4 applications

Semico's Desktop PC Outlook

- We expect Intel will roll out P4 with RDRAM but will be forced to accept independent DDR chipsets in 2H01
- We also expect Intel's Brookdale PC133 chipset to support DDR by end of 2001
- Athlon/DDR shows very good system-level performance at a competitive price
- AMD performance also covers the gap between P3 and P4

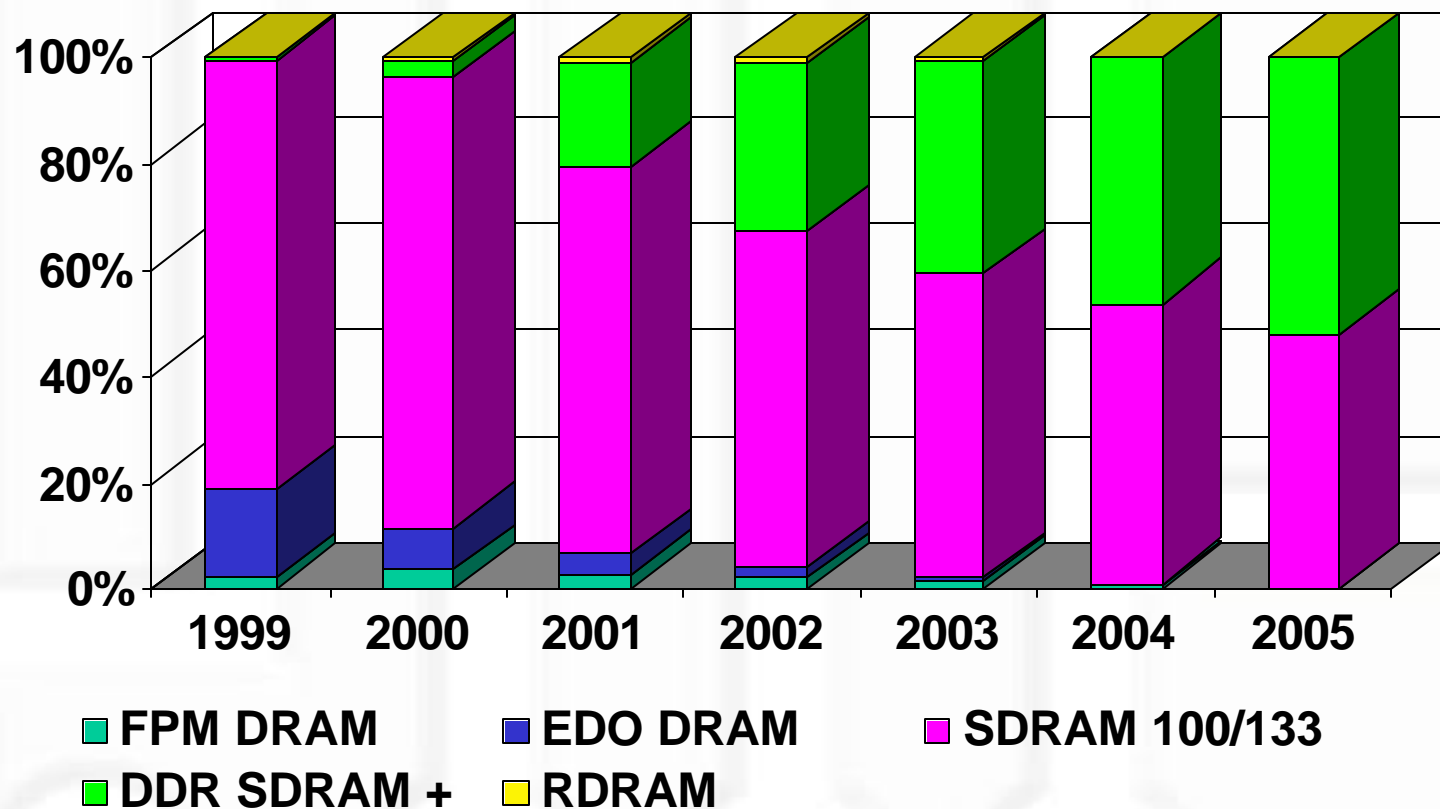
2001 DRAM Type Update

- DDR SDRAM ships in production volumes
 - Servers demonstrating DDR SDRAM systems
 - Delay in server chipsets will push out DDR SDRAM server demand to 1Q01
 - Majority of new designs for 2001 and beyond production expected to be DDR SDRAM
- RDRAM future still unclear
 - Plagued by high costs, low yield and limited number of suppliers
 - Major RDRAM rebates being offered tied to Pentium 4 rollout

Evolution versus Revolution

- PC133 demand soaring with 815e availability
- DDR is metal mask option for PC133 for most DRAM manufacturers
 - More flexibility for manufacturing
 - Gains from existing PC133 yield improvements
 - Chipset availability limited, but increasing
- RDRAM demand is low –
 - success in workstation niche, Playstation 2
 - waiting for P4 Ramp

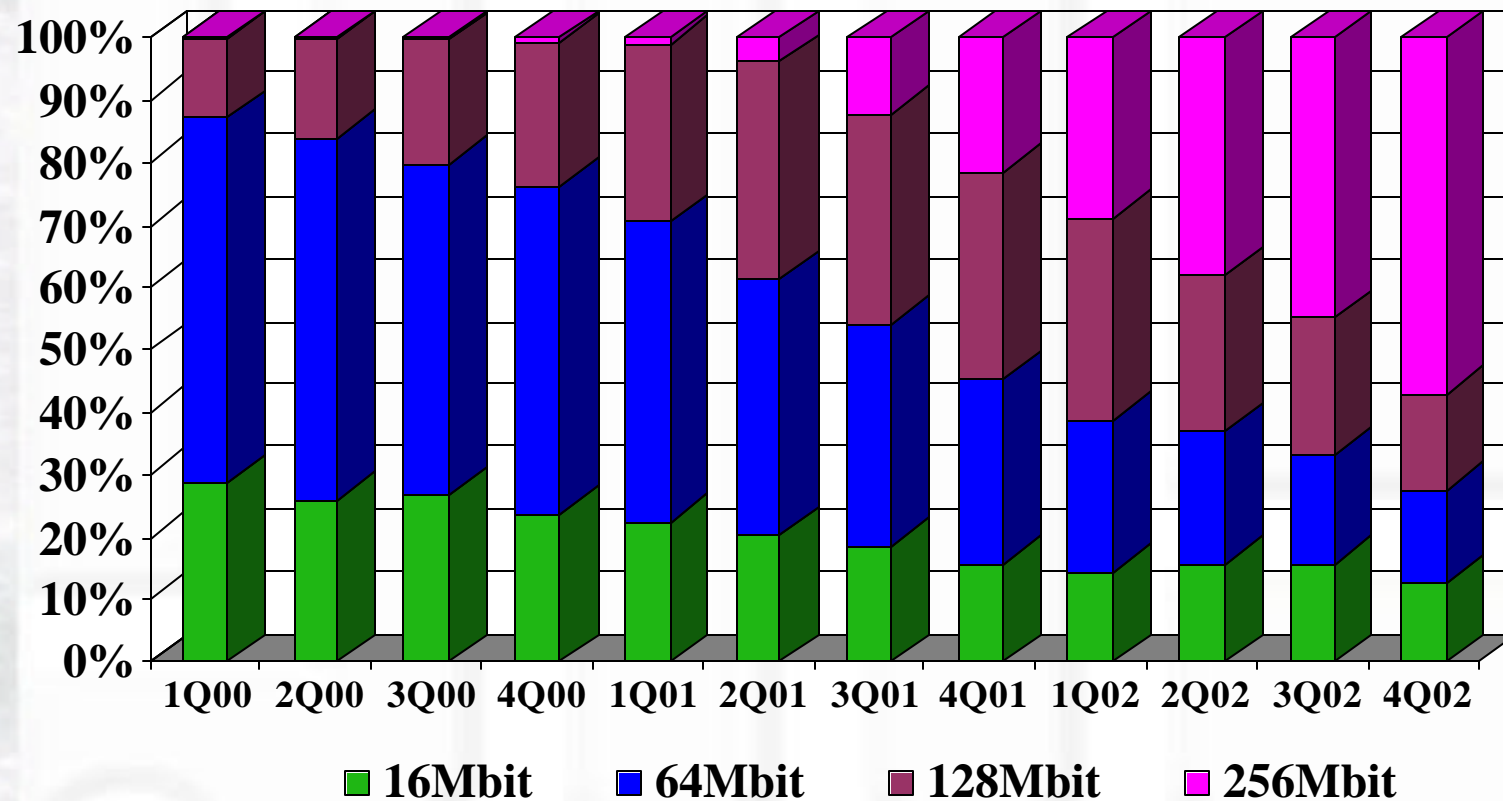
DRAM Units by Type



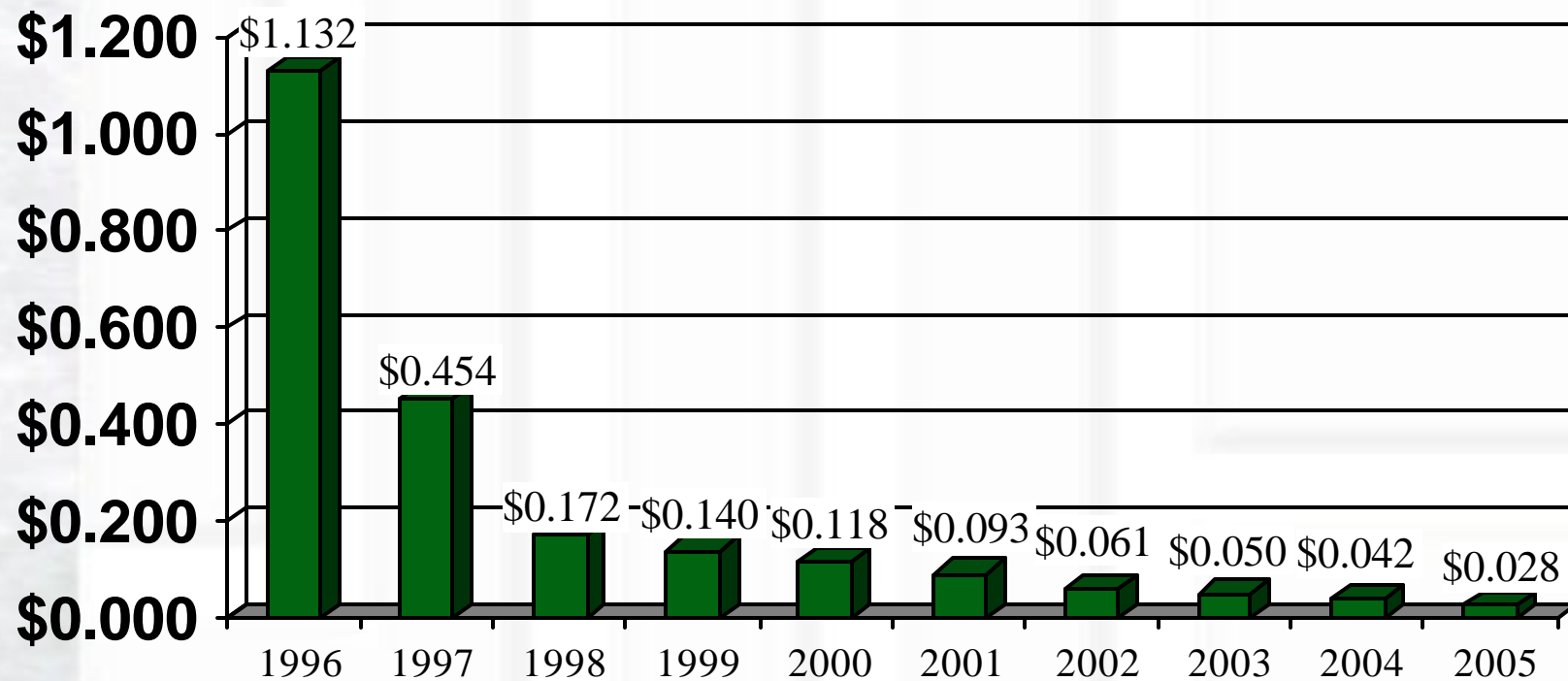
DRAM Trends

- End Use Segmentation
 - Older types and densities still in demand
 - Supply uncertain for older types
- Desktop and Notebooks
 - Highest volume in low cost segment
- Internet—New Features and Functions
 - New convergent product—combined computing, communication in consumer box

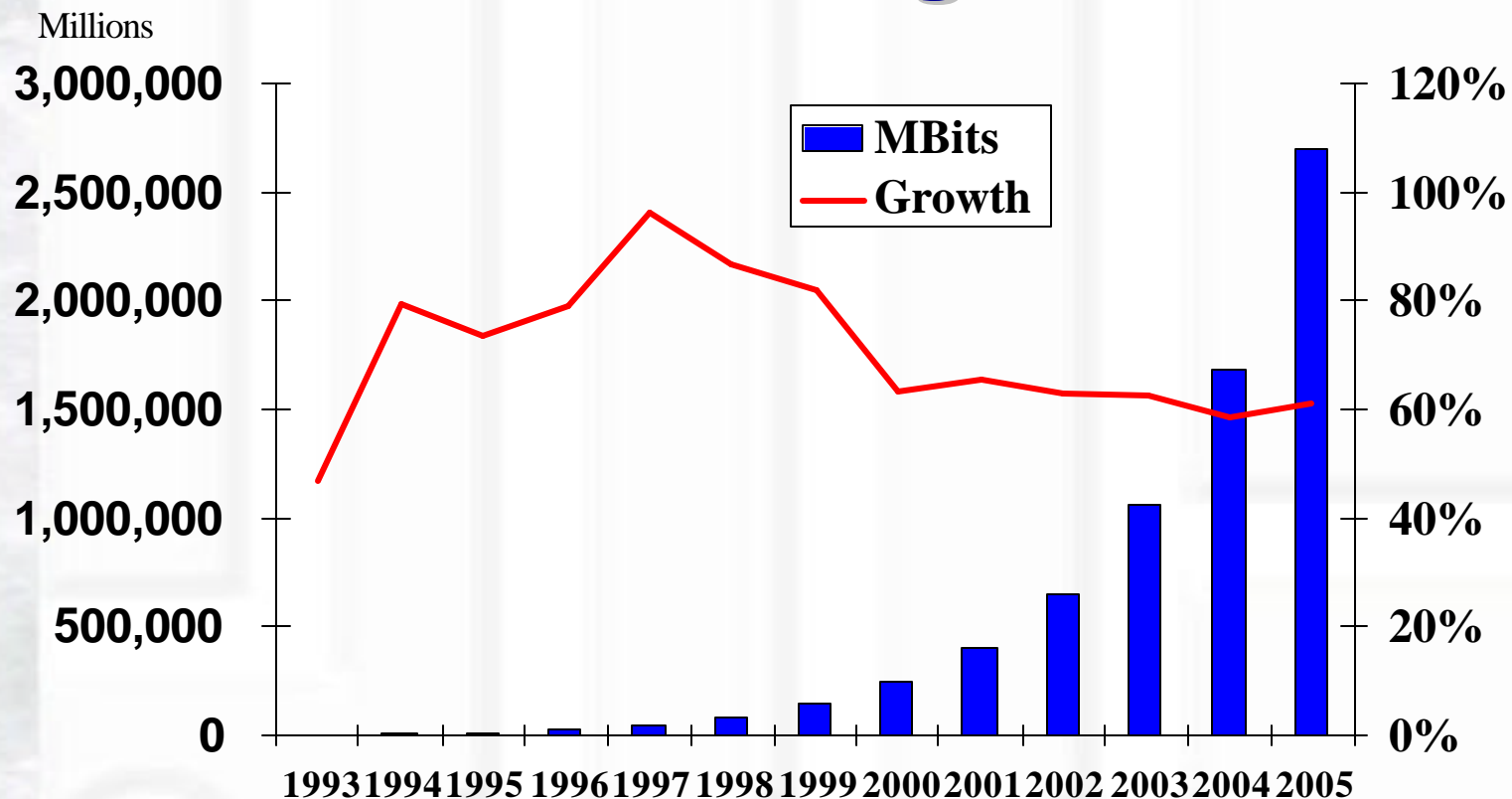
DRAM Unit Density Migration



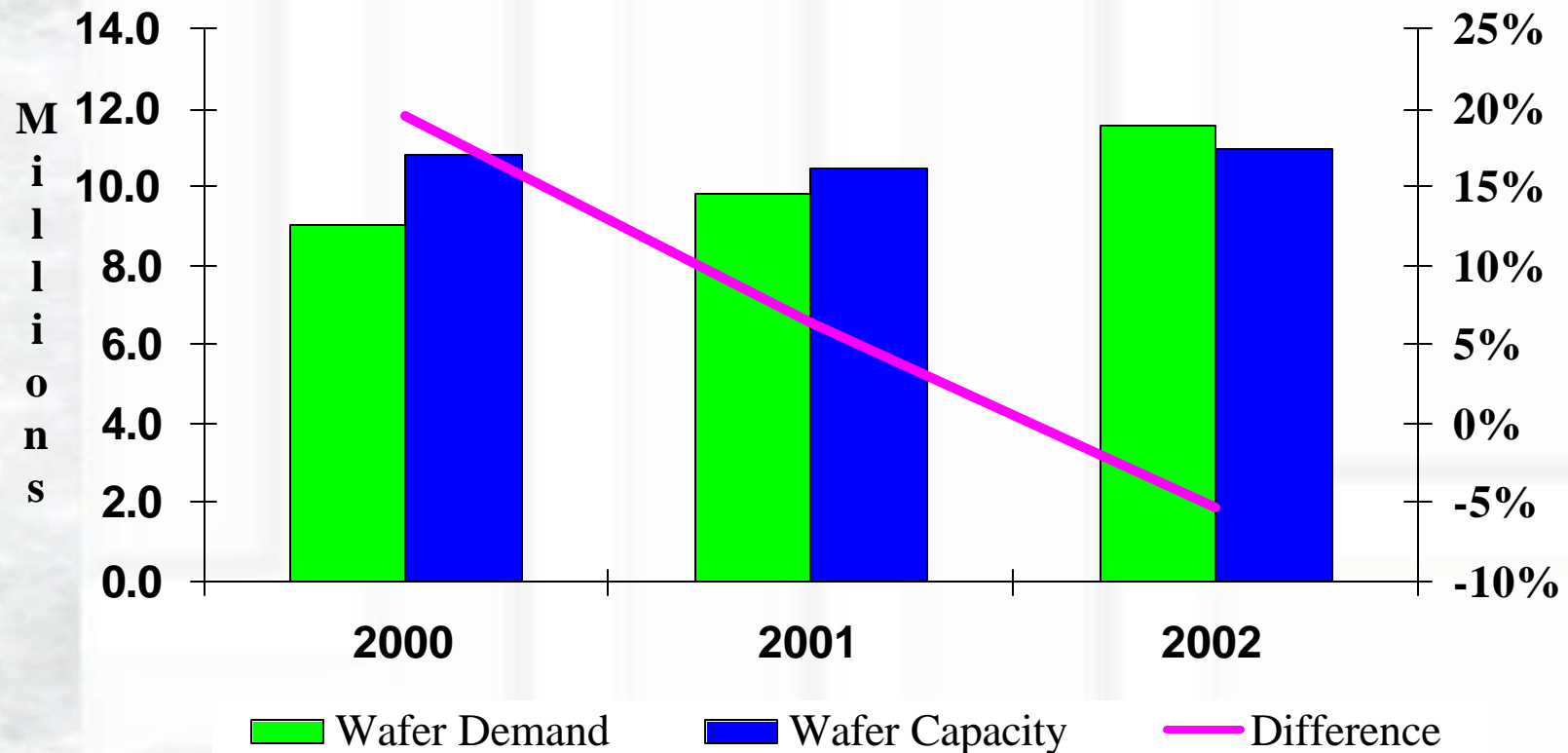
DRAM Cost Per Megabit



Megabit Shipments – Still Growing



Wafer Demand and Capacity



In Conclusion

- Expect the DRAM consolidation to continue until there are fewer than ten vendors. Consolidation may take until 2003.
 - DRAM vendors drop out as major capital investment becomes necessary and the segmentation of the DRAM market makes revenue generation more challenging.
- The cost of competition is too high to support numerous vendors.
 - Cost of 300mm production will limit number of vendors able to successfully invest.

Yet Even More In Conclusion

- Chipsets are becoming a bigger issue for the computer market and DRAM vendors
- Both PC OEMs and DRAM vendors are dependent upon chipset availability
- Chipset designs control PC architectures
- Chipset features influence future PC concepts

2001 and Beyond

- Chipset—the new product differentiator